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Ultra-high temperature ceramics containing $TaSi_2$

Laura Silvestroni, Diletta Sciti

CNR-ISTEC, Institute of Science and Technology for Ceramics, Via Granarolo 64, I-48018 Faenza, Italy

Abstract

ZrB_2 and HfB_2 possess a unique combination of properties, such as high melting point, high hardness and strength, good oxidation resistance and high thermal conductivity, which make them potential candidates for components in future hypersonic vehicles.

In this work, $TaSi_2$ was added to Zr and Hf borides, to promote the densification and improve the oxidation resistance.

The microstructure of the hot pressed composites was analyzed by X-ray diffraction, scanning and transmission electron microscopy to investigate the densification mechanisms occurring during sintering. The formation of (Ta,Me)B_2 solid solution surrounding the matrix was observed in both ceramics. The chemistry of secondary phases and triple points suggests that cation transfer is an active process and the presence of a liquid phase during sintering is confirmed.

Vickers hardenss, fracture toughness, elastic modulus, 4-pt bending strength up to 1500°C were evaluated. HfB_2-based ceramic exhibited the best properties and the strength in air at 1500°C was still 600 MPa.

Oxidation tests were carried out at 1600°C in air in order to assess the effectiveness of $TaSi_2$ as protective phase. Finally, arc-jet experiments in high enthalpy hypersonic flow were carried out on the HfB_2–based composite to evaluate the aerothermal behaviour on two models with hemispheric and cone-shaped geometry. Post test SEM analyses confirmed the excellent stability for this material.